On MCTS Tile Merger for CDN-based Viewport-dependent 360 Video Tiled Streaming

Presenter: Eun-Seok Ryu (esryu@skku.edu)
Jong-Beom Jeong, Soonbin Lee, Eun-Seok Ryu

Multimedia Computing Systems Lab. (MCSL)
http://mcsl.skku.edu
Department of Computer Education
Sungkyunkwan University
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Author(s): Jong-Beom Jeong, Soonbin Lee, Eun-Seok Ryu

<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
<th>Phone [optional]</th>
<th>Email [optional]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jong-Beom Jeong</td>
<td>Sungkyunkwan Univ.</td>
<td></td>
<td><a href="mailto:uof4949@skku.edu">uof4949@skku.edu</a></td>
</tr>
<tr>
<td>Soonbin Lee</td>
<td>Sungkyunkwan Univ.</td>
<td></td>
<td><a href="mailto:soonbinlee@skku.edu">soonbinlee@skku.edu</a></td>
</tr>
<tr>
<td>Eun-Seok Ryu</td>
<td>Sungkyunkwan Univ.</td>
<td></td>
<td><a href="mailto:esryu@skku.edu">esryu@skku.edu</a></td>
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360 Video Tiled Streaming

- High resolution and framerate for high-quality 360 video streaming
  - high bandwidth, high computational complexity
- Tiled streaming based on MCTS for viewport-dependent streaming
  - Bitstream extractor and merger (BEAMer) in CDN
  - Distributed computing for flexible device-adaptive streaming

![Diagram of 360 video tiled streaming system]

<table>
<thead>
<tr>
<th>Requirement</th>
<th>details</th>
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<tbody>
<tr>
<td>pixels/degree</td>
<td>40 pix/deg</td>
</tr>
<tr>
<td>video resolution</td>
<td>11520 × 6480</td>
</tr>
<tr>
<td>framerate</td>
<td>90 fps</td>
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Requirements for high quality VR
Source: Technicolor, Oct. 2016 (m39532, MPEG 116th Meeting)
Background

- MPEG System group proposed BEAMer to:
  - Prevent waste of decoding resources (low-quality pictures which are not rendered)
  - Time consumption because of several bitstreams

Implementation of Tile Merger

- In HEVC test model (HM) 16.20, a tile extraction SW is included
  - Tile merging SW is not included
- Used low-level entropy coding objects to implement fast merging
  - HM extractor uses high-level objects -> slower
- HEVC and VVC-compliant versatile MCTS merging
  - Mixed quality, mixed resolution tile/subpicture merging is available

System architecture of tile merger
Mixed Quality Tiled Streaming

- Tiles/subpictures are divided in compressed domain using MCTS
- High- and low-quality MCTS bitstreams at the server-side
- Tile/subpicture QP modification for mixed quality merging

\[
\text{SliceQPDelta} = \text{PPS} \rightarrow \text{QP}() - \text{initQPMinus26} + 26
\]

\[
\text{SliceQP} = \text{SliceQPDelta} + 26
\]

Example of mixed-quality viewport-dependent 360-degree video tiled streaming
Mixed Quality & Resolution Tiled Streaming

- Tiles/subpictures are divided in compressed domain using MCTS
- Mixed-quality and mixed-resolution MCTS bitstreams at the server-side
- HEVC and VVC-compliant versatile MCTS merging
  - Multiple slices aligned vertically in one tile/subpicture
  - Mixed quality, mixed resolution tile/subpicture merging is available

Example of mixed-quality and mixed-resolution viewport-dependent 360-degree video tiled streaming
Experimental Results

- HM 16.20 for encoding, ffmpeg git-2020-03-28-3362330 for decoding
- Intel i5-8250U (4 cores) and 8GB memory on the experimental device
- In merging, half of the tiles were HQ, the others were LQ
  - Quantization parameter (QP) 22 for HQ, 37 for LQ
  - Resolution 4096 × 2048 for HQ, 2048 × 1024 (down-sampled) for LQ
- Mixed quality & resolution saved 37.12% pixel rate and merging/decoding time

<table>
<thead>
<tr>
<th>Method</th>
<th>Tiling</th>
<th>Resolution</th>
<th>No. of merged tiles</th>
<th>QP</th>
<th>Merging time (s)</th>
<th>Decoding time (s)</th>
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<tbody>
<tr>
<td>Anchor</td>
<td>-</td>
<td>4096 × 2048</td>
<td>-</td>
<td>22</td>
<td>-</td>
<td>3.014</td>
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<tr>
<td>Anchor</td>
<td>-</td>
<td>4096 × 2048</td>
<td>-</td>
<td>37</td>
<td>-</td>
<td>2.543</td>
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<td>Mixed quality</td>
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<td>22, 37</td>
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<td>2.743</td>
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<td>4096 × 2048</td>
<td>32</td>
<td>22, 37</td>
<td>0.392</td>
<td>2.926</td>
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<tr>
<td>Mixed quality, mixed resolution</td>
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<td>8</td>
<td>22, 37</td>
<td>0.386</td>
<td>2.048</td>
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Merging, decoding performances of mixed quality, mixed quality & resolution tiled streaming
Experimental Results (Cont’d)

- Decoding by HM and ffmpeg without any problems
- At the tile boundaries, no visual errors were observed (successful merging)

Decoding example of mixed quality & resolution tiled streaming
Conclusion

• Motivation
  • High BW & computing time for 360-degree video streaming: tiled streaming can be used
  • Bitstream extractor and merger (BEAMer) in MPEG for:
    ➢ Preventing the waste of decoding resources including time consumption

• Proposed Methods and Insights
  • HEVC bitstream merger for mixed quality & resolution tiled streaming
  • Pixel rate, merging time, decoding time savings compared to the anchor
  • CDN-based system architecture for flexible client-adaptive streaming

• Future Work
  • Experiments on several tiling scenarios will be conducted